JANUARY, 1963

DEFENSE METALS INFORMATION CENTER

SELECTED ACCESSIONS

BATTELLE MEMORIAL INSTITUTE
505 King Avenue
Columbus 1, Ohio

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Compiled by:

Patricia B. Plate

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TABLE OF CONTENTS

	Page
AUTHOR INDEX	iii
SUBJECT INDEX	v
HIGH-STRENGTH ALLOYS	1
Cobalt Base	3
Nickel Base	4
Engineering Steels	5
Stainless Steels	7
Iron Base	9
LIGHT METALS	10
Beryllium	11
Titanium	12
Magnesium	13
Silicon	14
NONMETALLICS	15
Carbon, Graphite	16
Special Refractories	18
Ceramic Oxide	19
REFRACTORY METALS	21
Columbium	22
Molybdenum	23
Tantalum	24
Vanadium	25
Tungsten	26
Platinum Group	28
MISCELLANEOUS	29
Coatings	32
Applications	33
Composites	34

DMIC NUMERICAL INDEX

DMIC No.	Page	DMIC No.	Page	DMIC No.	Page	DMIC No.	Page
49550	7	49630	11	49665	12	49721	17
49552	34	49632	29	49666	24	49724	73
49558	10	49646	18	49672	29	49739	23
49560	5	49647	16	49693	29	49774	2
49569	22	49649	4	49695	35	49775	8
49572	16	49651	24	49697	5	49776	14
49574	26	49652	4	49702	12	49777	37
49576	26	49654	7	49703	35	49778	30
49577	26	49655	35	49704	36	49779	20
49579	5	49656	15	49705	36	49780	30
49597	21	49657	19	49706	36	49781	33
49608	34	49659	12	49707	12	49783	21
49612	34	49660	1	49708	30	49784	26
49613	7	49661	18	49709	1	49785	73
49618	19	49662	11	49711	16	49790	22
49623	11	49663	23	49712	16	49792	5
49629	11	49664	19				

AUTHOR INDEX

Author	DMIC No.	Page
A		
Anderson, M. S.	49775	8
B		
Bedell, S. F.	49706	36
Bell, W. J.	49613	7
Belser, R. B.	49704	36
Benham, P. B.	49613	7
Bomberger, H. B.	49663	25
Bouc, C. A.	49695	35
Brady, W. C.	49612	34
Brink, N. O.	49552	34
Burn, R. A.	49651	24
C		
Card, M. F.	49775	8
Carithers, M. D.	49704	36
Carnahan, D. R.	49739	23
Carstens, J. P.	49632	29
Chi, S. H.	49656	15
Conrad, H.	49597	21
Cornell, J. H.	49706	36
Crooks, D. D.	49577	26
D		
Davison, W. R.	49632	29
Debrunner, R. E.	49706	36
Delaney, L. J.	49721	17
de Ruiter, E.	49572	16
E		
Eimer, E. H.	49703	35
Elkins, S. R.	49657	19
Elliott, R. P.	49665	12
F		
Forray, M. J.	49709	1
Frank, R. G.	49790	22
Freeman, J. W.	49781	33
G		
Gagne, R. A.	49579	5
Gelles, S. H.	49662	11
Gilman, L.	49706	36
Gloria, H. R.	49655	35
Graham, T. L.	49705	36
Graziano, E. E.	49777	37
Gregory, D. P.	49783	21
H		
Halleux, A.	49572	16
Harrison, W. N.	49672	29
Hathaway, C. E.	49706	36
Hickox, G. K.	49784	26
Hirsch, P. B.	49666	24
I		
Imai, M.	49711	16
Irwin, G. R.	49558	10
J		
Jacobs, F.	49654	7
Jenkins, P. C.	49652	4
Jensen, J. W.	49785	13
Johnston, O. E.	49550	7
Jones, W. H.	49721	17
Jorgensen, P. J.	49776	14
K		
Karten, M. J.	49706	36
Kattus, J. R.	49652	4
Kelsey, R. H.	49661	18
Kendall, E. G.	49646	18
Kerper, M. J.	49703	35
Krafft, J. M.	49558	10
L		
Leipold, M. G.	49664	19
Lement, B. S.	49666	24
Levinson, D. W.	49659	12
Logan, H. L.	49792	5
M		
Merrifield, W. P.	49630	11

Author	DMIC No.	Page
M		
Morrison, A. R.	49612	34
Morrison, J. D.	49652	4
Murphy, C. A.	49657	19
Murray, G. T.	49651	24
N		
Neff, C. W.	49790	22
Newman, M.	49709	1
Nielsen, T. H.	49664	19
Nilsson, D.	49693	29
O		
O'Connell, J. J.	49706	36
Owen, W. S.	49666	24
P		
Perkins, R. A.	49577	26
Petersen, V. C.	49663	25
Poulos, N. E.	49657	19
Price, W. L.	49577	26
Probert, L. E.	49697	5
R		
Rabinowicz, E.	49711	16
Raynes, B. C.	49661	18
Richardson, J. H.	49647	16
Richmond, J. C.	49672	29
Robbins, W. P.	49550	7
Rollinson, J. J.	49697	5
Rosen, J. M.	49629	11
Rowe, G. H.	49783	21
Rowland, J. A.	49785	13
S		
Sandor, V.	49572	16
Savin, R. C.	49655	35
Schoenfeld, W. J.	49574	26
Scott, T. E.	49660	1
Scuderi, T. G.	49703	35
Skramstad, H. K.	49672	29
Soffa, L. L.	49623	11
Spence, G. B.	49712	16
Steverding, B.	49774	2
Stewart, W. J.	49655	35
Streed, E. R.	49778	30
Stroh, A. N.	49783	21
Sullivan, A. M.	49558	10
Switzky, H.	49709	1
T		
Tarwater, J.	49560	5
Thomas, D. A.	49666	24
Torgerson, R. T.	49569	22
Troiano, A. R.	49660	1
Tschamler, H.	49572	16
Turrentine, D.	49708	30
V		
Vila, V. M.	49693	29
Visconti, J. A.	49739	23
Voorhees, H. R.	49781	33
W		
Walsh, D. F.	49785	13
Walton, J. D.	49657	16
Weissmann, S.	49666	24
Whitehouse, I.	49560	5
Wiederhorn, N. M.	49780	30
Wilson, H. H.	49618	19
Wong, R.	49612	34
Z		
Zehms, E. H.	49647	16

SUBJECT INDEX

	DMIC No.	Page
HIGH-STRENGTH ALLOYS		
Fracture Strength	49660	1
Notch Toughness	49774	2
Thermoelastic Analysis	49709	1
Cobalt Base		
Tensile Properties	49652	4
Nickel Base		
Adhesive Bonding	49550	7
Arc Welding	49649	4
Crack Propagation	49652	4
Fiber Reinforced	49661	18
Tensile Properties	49652	4
Engineering Steels		
Crack Generation	49560	5
Extrusion	49579	5
Fatigue-Crack Sensitivity	49560	5
Hydrogen Embrittlement	49697	5
Metallographic Examination	49579	5
Reduction Ratio	49579	5
Stress-Corrosion Cracking	49792	5
Tensile Strength	49579	5
Tensile Tests	49560	5
Stainless Steels		
Adhesive Bonding	49550	7
Bending Test	49775	8
Fatigue Life	49707	12
Fatigue Testing	49613	7
Mechanical Properties	49654	7
Plastic Stress	49707	12
Reflective Coatings For	49704	36
Shear Forming	49654	7
Strain Distribution	49781	33
Iron Base		
Tensile Properties	49652	4
LIGHT METALS		
Fracture-Toughness Test	49558	10

	DMIC No.	Page
LIGHT METALS (Continued)		
Beryllium		
Electron Microscopy	49662	11
Fluorescent-Penetrant Inspection	49630	11
Metallographic Studies	49623	11
Plating	49623	11
	49630	11
Purification	49662	11
Radiographability	49629	11
Welding	49662	11
Titanium		
Diffusion	49665	12
Embrittlement	49659	12
Fatigue Life	49707	12
Mechanical Properties	49654	7
Phase Study	49659	12
Plastic Stress	49707	12
Self-Diffusion Curves	49665	12
Shear Forming	49654	7
Magnesium		
Casting, Fabrication	49724	13
Damping	49785	13
Microstructure Studies	49785	13
Production	49724	13
Tensile	49785	13
Silicon		
Oxidation	49776	14
NONMETALLICS		
Bibliography	49656	15
Damping	49656	15
Young's Modulus	49656	15
Carbon, Graphite		
Corrosion	49721	17
Dislocation Theory	49712	16
Fabrication	49572	16
Friction and Wear	49711	16
Pyrolytic Graphite	49647	16
Thermal Stress	49721	17
Special Refractories		
Alumina Whiskers	49661	18

	DMIC No.	Page
NONMETALLICS (Continued)		
Brittle Fracture	49597	21
Mechanical Properties	49646	18
Physical Properties	49646	18
Processing	49646	18
Pyrolytic Boron Nitride	49711	16
Ceramic Oxide		
Beryllium Oxide	49779	20
Brittle Fracture	49597	21
Fabrication	49779	20
Fused Silica	49657	19
Heat Treatment	49618	19
Magnesium Oxide	49618	19
Mechanical Properties	49646	18
Physical Properties	49646	18
Processing	49646	18
Thermal Expansion	49664	19
REFRACTORY METALS		
Adhesive Bonding	49550	7
Bibliography	49783	21
Ductile-to-Brittle Transition	49597	21
Work Hardening	49783	21
Columbium		
Coatings on	49790	22
Costability	49569	22
Ductile-Brittle Transition	49569	22
	49652	4
Fabrication	49790	22
Forming	49569	22
Recrystallization	49569	22
Substructural Characteristics	49666	24
Tensile Properties	49569	22
Molybdenum		
Ductile-Brittle Transition	49652	4
Extrusion	49739	23
Forging	49739	23
Mechanical Properties	49739	23
Rolling	49739	23
Substructural Characteristics	49666	24
Tantalum		
Ductile-Brittle Transition	49651	24

	DMIC No.	Page
REFRACTORY METALS (Continued)		
Substructural Characteristics	49666	24
Vanadium		
Elevated-Temperature Alloys	49663	25
Forgeability	49663	25
Hot Hardness	49663	25
Microstructure	49663	25
Tungsten		
Bonding	49576	26
Brazing	49784	26
Diffusion Bonding	49784	26
Ductile-Brittle-Bend Transition	49574	26
Ductile-Brittle Transition	49652	4
Extrusion	49574	26
	49739	23
Forging	49739	23
Mechanical Properties	49739	23
Oxidation	49577	26
Reaction Kinetics	49577	26
Rolling	49739	23
Shear Forming	49576	26
Sheet Rolling	49574	16
Spinning	49576	26
Substructural Characteristics	49666	24
Tensile Properties	49574	26
Platinum Group		
Reflective Coatings of	49704	36
MISCELLANEOUS		
Ablation	49693	29
Bibliography	49780	30
Space Environment	49780	30
Space Storability of Propellants	49632	29
Thermal Analysis	49708	30
Thermal-Emittance Measurements	49672	29
Thermal Protection	49655	35
	49778	30
Thermal-Stress Theory	49775	8
Vacuum Environment	49655	35
Coatings		
Arc Plasma Glazing	49657	19
LB-2	49790	22

	DMIC No.	Page
MISCELLANEOUS (Continued)		
Applications		
Armor	49724	13
Expandable Structures	49705	36
Fasteners	49724	13
	49790	22
Honeycomb Sandwich	49550	7
Nozzle Components	49576	26
Radiative-Properties Apparatus	49778	30
Radome	49657	19
Re-Entry Heat Shield	49647	16
Re-Entry Vehicles	49708	30
Sandwich Structures	49777	37
Solid Propellant Rocket Throat Inserts	49721	17
Strain Gages	49781	33
Thrust Chamber	49774	2
Viewing Windows	49703	35
Composites		
Adhesives	49550	7
Bibliography	49777	37
Compression	49552	34
Creep	49703	35
Fabrication	49608	34
Fibers	49608	34
	49656	15
Filament Winding	49695	35
Flexural Strength	49706	36
Flexure	49552	34
Glass	49703	35
Glass Fibers	49612	34
Laminates	49706	36
Low Temperature Effects	49552	34
Metal Sandwiches	49777	37
Microscopic Studies	49695	35
Mode of Fracture	49695	35
Plastic	49656	15
Plastics	49655	35
Polymeric Coatings	49704	36
Reflective Coatings	49704	36
Resin System	49705	36
Stress Rupture	49703	35
Tensile Fatigue	49552	34
Tensile Strength	49612	34
Tension	49552	34

DEFENSE METALS INFORMATION CENTER

Selected Accessions

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HIGH-STRENGTH ALLOYS

49660 INTERSTITIAL INDUCED DELAYED FAILURE OF STEEL. T. E. Scott and A. R. Troiano, Case Institute of Technology, Cleveland, Ohio. ARL 62-425, September 1962, Contract No. AF 33(616)-6419
(35 references, 41 pages, 12 figures, 2 tables)

Similarities in the delayed failure characteristics of hydrogenated high-strength steel and a non-hydrogenated high-temperature die steel tested at elevated temperatures were evaluated and compared. The almost perfect correspondence of the behavior of the two systems led to the conclusion that the same mechanism was operative in both cases. This mechanism is based on the idea of a local lowering of the cohesive strength of the lattice due to an accumulation of interstitial-solute atoms to regions of high-elastic strain.

A correlary phenomenon, general deterioration, was observed in the high-temperature steel as a lowering of the true-fracture strength of delayed failure test specimens. The rationalization of this behavior was also based on the above mechanism.

49709 THERMO-STRUCTURAL ANALYSIS MANUAL. M. J. Forray, M. Newman, and H. Switzky, Republic Aviation Corporation, Farmingdale, New York. WADD TR 60-517, Volume II, October 1962, Final Report, Contract No. AF 33(616)-6066
(numerous references, numerous figures, numerous tables)

Beam columns with axial end restraints and end loads coupled with transverse load and temperature gradients through the depth are analyzed.

Nondimensional curves are presented for the approximate analysis of the buckling and load determination of restrained columns with eccentricities induced by mechanical loads and thermal environment.

Large deflections of axially restrained, heated and loaded circular plates are treated.

The general equation for linear thermoelastic analysis of axisymmetric shells is developed. Cylinders and cones are discussed.

49774 MATERIAL OPTIMIZATION FOR LIQUID PROPULSION SYSTEMS. B. Steverding, U. S. Army Missile Command, Redstone Arsenal, Alabama. Report No. RR-TR-62-7, November 8, 1962
(3 references, 23 pages, 3 tables)

A mathematical method is developed by means of which the suitability of materials for the construction of liquid-propellant-thrust chambers is determined. Among the various candidate materials, alloys with specific property spectra are evaluated so that the basic function of a heat-exchanger material is satisfied under conditions of high strength, minimum weight, reliability, and short-time application.

A dimensionless factor is calculated for a number of candidate alloys which determines the feasibility of the specific metal for thrust-chamber construction.

Cobalt Base

49652 See Nickel Base.

Nickel Base

49550 See Stainless Steels.

49649 INERT GAS TUNGSTEN ARC WELDING OF INCONEL ALLOY 718 WITH RENE 41 FILLER METAL. International Nickel Company, Huntington Alloy Products, Huntington, West Virginia. November 28, 1962, Data Sheet
(4 pages, 3 figures)

This report summarizes the most recent work on the welding of INCONEL alloy 718. As a result of this work, the current recommendations for the welding of INCONEL alloy 718 are: (1) the inert gas tungsten-arc welding process, and (2) Rene' 41 filler metal.

49652 AN INVESTIGATION OF THE CRACK-PROPAGATION RESISTANCE OF HIGH-STRENGTH ALLOYS AND HEAT-RESISTANT ALLOYS. J. D. Morrison, P. C. Jenkins, and J. R. Kattus, Southern Research Institute, Birmingham, Alabama. 5603-1256-X, November 21, 1962, Summary Technical Report, Bureau of Naval Weapons, Contract No. NOw 61-0392-d
(11 references, 95 pages, 29 figures, 41 tables)

The purpose of this program was to determine the crack-propagation resistance of super-alloy and refractory-metal sheet materials and to investigate certain aspects of the elevated-temperature mechanical behavior of high-strength low-alloy steels. Sheet specimens containing central-transverse fatigue cracks were used in the experimental work. It was found that the fracture toughness of the nickel-base alloys--Rene' 41, Nimonic 90, Inconel-X, and Unitemp 1753--decreased slightly in the temperature range from about 1000 F to 1400 F, in which temperature range there were generally increases in ultimate-tensile strength and decreases in tensile elongation. The alloys A286 and L605 did not show this brittleness tendency. Among the refractory metals, unalloyed molybdenum was found to have a brittle-ductile transition temperature of about 150 F; the molybdenum alloys--Mo-1/2%Ti and TZM--both had transition temperatures of about 65 F. Unalloyed tungsten sheet, containing sharp notches rather than fatigue cracks, showed an increasing tendency to brittleness below about 500 F. Two columbium-base alloys--D-14 and FS82--were ductile over the temperature range investigated--from -320 F to about 1000 F. In an investigation of apparent strain-aging effects in steels, it was found that greatly increasing the rage of loading diminished the net-fracture-stress minimum that occurs at around 300 F at slow-loading rates.

49661 See Special Refractories.

Engineering Steels

49560 FATIGUE CRACK SENSITIVITY AS A FUNCTION OF FATIGUE LOAD AND METHOD OF LOADING. I. Whitehouse and J. Tarwater, Republic Steel Corporation, Canton, Ohio. August 14, 1962, Paper
(7 pages, 4 figures, 3 tables)

Though fatigue cracking is becoming more routine, there are, to the author's knowledge, no specifications available defining the acceptable properties of a fatigue crack or the conditions under which it is formed. The purpose of this report is to show that the notch strength of a center-notched-tensile-test specimen is a function of crack preparation and that recommendations regarding crack generation should be considered.

49579 EFFECT OF BILLET HISTORY ON HOT EXTRUDED PROPERTIES OF 1020, 4330, and SI - MODIFIED 4340 STEEL. R. A. Gagne, Watertown Arsenal Laboratory, Watertown, Massachusetts. WAL TR 310.22/3, September 1962, Technical Report
(32 pages, 28 figures, 6 tables)

Three types of steels (1020, 4330 and Si-modified 4340 steel), each with four different billet histories, were hot extruded. This report describes the effects studied with the extruded material in both the as-extruded and the extruded-plus-heat-treated conditions. The studies included tensile tests, metallographic examination and the effect of location along the length of the extrusion.

49697 HYDROGEN EMBRITTLEMENT OF HIGH TENSILE STEELS DURING CHEMICAL AND ELECTRO-CHEMICAL PROCESSING. L. E. Probert and J. J. Rollinson, Electroplating and Metal Finishing, v. 15, no. 7, July 1962, p. 228-232
(5 pages)

It is shown that hydrogen absorbed during processing is not a problem if treated correctly. Hydrogen embrittlement depends on a number of factors including the carbon content and ultimate tensile strength of the steel and the contaminating properties of the particular process involved, but in every instance attempted by the authors, complete recovery was achieved by suitable de-embrittlement heat treatment. It is felt that conditions of embrittlement are directly associated with differential pressures at the surface of high tensile steels. Low hardness materials permit the complete passage of hydrogen, but above the critical level for embrittlement this movement is restricted by internal pressure to produce a super-saturated surface layer of atomic hydrogen which acts as a reservoir for embrittlement cracking under conditions of stress.

49792 STUDIES OF THE STRESS-CORROSION CRACKING OF LOW-CARBON STEELS. H. L. Logan. Engineering & Instrumentation, Journal of Research, National Bureau of Standards, v. 66C, no. 4, Oct.- Dec. 1962, p. 347-356
(19 references, 10 pages, 12 figures, 2 tables)

The mechanism of stress-corrosion cracking in low-carbon steels was investigated using notched specimens, stressed in tension to produce a slight amount of plastic deformation, and exposed in a boiling 20 per cent

49792 (Continued)

aqueous solution of NH_4HO_3. Initiation and propagation of cracks were studied by removing specimens for metallographic examination after stated periods of exposure and by simultaneously recording extensions and electrochemical-solution potentials. Cracks were initiated after about 20-minutes' exposure and complete failures occurred in 200 minutes or more. Both crack initiation and propagation were postulated to result from an electrochemical process in which the anodic areas were submicroscopic. Tensile fractures were prevented from going to completion because of the energy involved in forming the surfaces of the cracks and the strain hardening and the strain aging of the steel at the tips of the cracks.

Stainless Steels

49550 RESEARCH ON INORGANIC HIGH TEMPERATURE ADHESIVES FOR METALS AND COMPOSITE CONSTRUCTIONS. O. E. Johnston and W. P. Robbins, Aeronca Manufacturing Corporation, Middletown, Ohio. WADC TR 59-113, Part III, May 1962, Final Report, Contract No. AF 33(616)-5538 and AF 33(616)-7196
(67 references, 241 pages, 63 figures, 84 tables)

This contract was for the purpose of conducting research on high-temperature inorganic non-polymeric adhesives for metal-to-metal bonding, for applications as high as the 2000 to 3000 F range.

The practical application of inorganic non-polymeric adhesives as a joining material for high-temperature-resistant metals has been achieved. The following research has been accomplished:

(1) Fabrications and evaluation of experimental inorganic non-polymeric adhesives
(2) Preparation and application of the inorganic adhesives to the metal adherends
(3) Improvement of flexibility, toughness, and strength of the adhesive to obtain a highly efficient bond for use in joining the high-temperature resistant metals such as 17-7 PH, PH 15-7 Mo, AM-350, Inconel "X"
(4) Processing research for optimum joining of honeycomb-sandwich structures with inorganic adhesives
(5) Evaluation of bonded honeycomb panels for structural integrity and capability
(6) Refractory-metals-inorganic adhesives bonded with retention of useful bond strength in the 1800 to 2000 F temperature range.

49613 THE EFFECT OF MEAN STRESS ON THE FATIGUE OF PLAIN AND NOTCHED STAINLESS STEEL SHEET IN THE RANGE FROM 10 TO 10^7 CYCLES. W. J. Bell and P. P. Benham, Rexall Chemical Company, Odessa, Texas & Imperial College, London, England. Preprint of paper presented at the 4th National Meeting of the American Society for Testing & Materials, Los Angeles, California, October 1-5, 1962
(17 references, 16 pages, 18 figures, 2 tables)

Stainless steel sheet (18Cr 9 Ni) was fatigue tested under axial-load cycling in plain and notched conditions. Various stress ratios were employed ranging from R = - 1.0 to + 0.91, and endurances from 10 to 10^7 cycles were covered using testing frequencies of 5 - 15 and 3000 cycles per min.

A fatigue-strength-reduction factor based on maximum stress for a particular mean stress and endurance provided the most reliable correlation between plain and notched data.

49654 MECHANICAL PROPERTIES OF MATERIALS FABRICATED BY SHEAR FORMING. F. Jacobs, Temco Electronics and Missiles Company, Dallas, Texas. ASD TDR 62-830, August 1962, Contract No. AF 33(616)-7874
(15 references, 345 pages, 101 figures, 15 tables)

The severe plastic deformation that occurs during the shear-forming process requires that consideration be given the resultant effects on material properties.

49654 (Continued)

The effect of shear forming on the mechanical properties was determined for thirty-two alloys. The eight different classes of alloys included: (a) austenitic, ferritic, martensitic and precipitation-hardening types of stainless steels, (b) super alloys, (c) titanium alloys, (d) alloy steels, and (e) aluminum alloys.

All materials were shear formed into cones with room temperature reductions of 20, 30, 40, 50, 60, and 70 per cent. Each cone was formed with one pass of the shear-form roller. Some alloys did not withstand the higher per cent reductions.

Orginal material properties, properties after shear forming, and properties after shear forming plus heat treatment were determined. The typical microstructures of the various materials and conditions were recorded.

49704 See Composites.

49707 See Titanium.

49775 BUCKLING OF RING-STIFFENED CYLINDERS UNDER A PURE BENDING MOMENT AND A NONUNIFORM TEMPERATURE DISTRIBUTION. M. S. Anderson and M. F. Card, Langley Research Center, Langley Station, Hampton, Virginia. TN D-1513, November 1962, for NASA
(5 references, 32 pages, 13 figures)

Thirteen stainless-steel ring-stiffened cylinders were subjected to a pure bending load and heated rapidly until buckling occurred. For most of the cylinders the heating was not uniform around the circumference so that appreciable axial-thermal stresses were present. Elementary thermal-stress theory was found to be inadequate for the prediction of these thermal stresses, but a method was developed that would give satisfactory thermal-stress results. By properly accounting for the thermal stress, the buckling load could be correlated with a theory for the buckling of an axially-compressed ring-stiffened cylinder that is uniformly heated.

49781 See Applications.

Iron Base

49652 See Nickel Base.

LIGHT METALS

49558 A NEW SPECIMEN DESIGN FOR FRACTURE TOUGHNESS TESTS. G. R. Irwin, J. M. Krafft, and A. M. Sullivan, U. S. Naval Research Laboratory, Washington, D. C. Memorandum. August 21, 1962, To: ASTM FTHSSM Committee, Meeting in Seattle, August 27-28, 1962
(3 references, 5 pages, 8 figures)

This report discusses a new specimen design for fracture toughness tests.

In many respects the descriptive parameter of fracture toughness K_{Ic} (plane strain) is to be preferred over its counterpart K_c (plane stress). Representing as it does the first, or opening, mode of separation as flat fracture, it is characteristic of situations where small cracks or thick sections exist. It is insensitive to section size; occurs at a lower load; and requires no measurement of moving crack length (as by ink straining, etc.).

Given these advantages of the plane strain parameter, a sheet specimen designed specifically for its determination is discussed.

Beryllium

49623 METALLURGICAL INVESTIGATION OF IMPURITIES IN HOT PRESSED BERYLLIUM VERDAN MEMORY DISC. L. L. Soffa, TR 62-377. August 19, 1962
(4 pages)

The Materials and Processes Laboratories performed metallographic studies of hot pressed beryllium. In addition, an attempt was made to identify the impurities as they relate to current production problems in plating precision instruments fabricated from Beryllium. The identity of these inclusions may serve as a basis for changing the processing methods currently employed for plating the material at Autonetics.

49629 RADIOGRAPHY OF BERYLLIUM. J. M. Rosen. TR 62-341, July 13, 1962
(8 pages, 2 figures, 2 tables)

The purpose of this investigation was to evaluate the radiographability of beryllium of various thicknesses and to determine methods of improving upon the standard techniques.

For each exposure described the kilovoltage and milliamperage were held constant and the time was adjusted to yield a film density of 1.7 to 2.0. The work was done at Aircraft X-ray Corporation on a 100 KV Universal X-Ray Machine with beryllium window and 1.5 mm focal spot. The focus-film distance was 51 inches and Gavaert D-4 film was employed with a Kodak X-Omat film processor.

49630 EVALUATION OF THE EFFECT OF FLUORESCENT PENETRANT INSPECTION OF THE SUBSEQUENT PLATING OF BERYLLIUM. W. P. Merrifield. TR 62-352, August 1, 1962
(5 pages, 3 figures, 2 tables)

Investigation has shown fluorescent penetrant inspection to be a very effective method of detecting voids, inclusions, cracks or other surface discontinuities in beryllium as it is in other metals. If fluorescent-penetrant inspection is used in conjunction with X-ray inspection, a high grade beryllium basis metal can be assured for plating purposes. However, due to the large number of different penetrant-testing methods and the lack of familiarity with proper methods of application and removal of penetrants, the use of all penetrants has been reputed to cause attack of the beryllium basis metal and poor adhesion of the subsequent electrodeposits.

The results of such a study, which included various fluorescent-penetrant cycles and cleaning procedures, is reported herein.

49662 BERYLLIUM RESEARCH AND DEVELOPMENT PROGRAM. S. H. Gelles, Nuclear Metals, Inc., Concord, Massachusetts. ASD TDR 62-509, Volume I, October 1962, Final Report, Contract No. AF 33(616)-7065
(15 references, 202 pages, 102 figures, 23 tables)

This report describes work in the field of purification, joining, and flow and fracture. Volume I describes the preparation of high purity beryllium by the decomposition of BeI_2, and the joining of beryllium by ultrasonic welding. Also, a study of the distribution of BeO and voids in beryllium by replication-electron microscopy, an investigation of the brittle behavior of beryllium by transmission-electron microscopy, and a study of surface damage in beryllium are described.

Titanium

49654 See Stainless Steels.

49659 INVESTIGATION OF FACTORS RELATED TO AN UNKNOWN PHASE IN B120 VCA TITANIUM ALLOY. D. W. Levinson, Armour Research Foundation of Illinois Institute of Technology, Chicago, Illinois. ASD TDR 62-534, October 1962, Final Report, Contract No. AF 33(616)-8149
(9 references, 62 pages, 28 figures, 9 tables)

A study was made of the needle-like precipitate which had been observed to occur in B120 VCA as a result of welding or of solution treating at temperatures above 1100 C. The phase was found to be the alpha phase, stabilized by oxygen. Under conditions of strict oxygen exclusion the alpha needles do not appear.

The embrittlement of material aged after either welding or overheating during solution treatment was found to be unaffected by the alpha needles. Embrittlement occurred whether or not needles were present in the microstructure. Some evidence is presented which implies that omega phase precipitation may produce the embrittlement.

49665 DIFFUSION IN TITANIUM AND TITANIUM ALLOYS. R. P. Elliott, Armour Research Foundation of Illinois Institute of Technology, Chicago, Illinois. ASD TDR 62-561, October 1962, Final Report, Contract No. AF 33(616)-7656
(33 references, 57 pages, 16 figures, 6 tables)

The self-diffusion of Ti and the interdiffusion of Al, Zr, Mo, V, and O in Ti have been investigated in the temperature range 600-1300 C. Diffusion couples were prepared by roll-bonding or press-bonding. Electron-microprobe methods were used to determine the penetration of the substitutionally dissolved penetration of interstitially dissolved oxygen.

The electron microprobe analysis could not be used to determine the penetration curves of Al in Ti because of the very high absorption of characteristic Al x-radiation by Ti.

The self-diffusion of Ti was investigated by studying penetration of Ti^{44}, formed by bombarding scandium with protons. Diffusion couples were formed by dissolving Ti^{44}-enriched TiO_2 into the Ti.

The diffusion equations for Mo and V in α-Ti, and for the self-diffusion of Ti must be considered preliminary.

49707 EFFECT OF COMPRESSIVE LOADS ON STRUCTURAL FATIGUE AT ELEVATED TEMPERATURE. Douglas Aircraft Company, Inc., Long Beach, California. ASD TDR 62-448, October 1962, Final Report, Contract No. AF 33(616)-8103
(21 references, 159 pages, numerous figures, numerous tables)

The effects of compressive loads on structural fatigue at elevated temperatures are investigated using plain, notched, and welded Titanium 8Al-1Mo-1V, and PH 15-7Mo stainless steel coupon specimens. Specimens are subjected to Mach 3 spectrum-test environment, including compressive loads. Fatigue-life predictions are compared with spectrum-test results. The influence of prior stress-strain history on subsequent life is considered. Prediction methods are extended to include the compression range, and results are compared with spectrum tests. Plastic-stress distribution of notched specimens is determined analytically and experimentally. A variety of individual variable fatigue tests are performed at temperatures up to 900 F.

Magnesium

49724 NEW CHALLENGES IN...MAGNESIUM. Proceedings of the 18th Annual Convention of the Magnesium Association, Los Angeles, California. October 15-17, 1962, (18 papers)

This collection of papers encompasses the development, production, casting, fabrication, and applied engineering aspects of magnesium and magnesium alloys. Seven of the eighteen papers deal with the casting of magnesium. Six of the papers present the use of magnesium in aerospace applications. The remains concern the use of magnesium in chain saws, fasteners, and armor.

49785 VIBRATION DAMPING CAPACITY OF VARIOUS MAGNESIUM ALLOYS. D. F. Walsh, J. W. Jensen, and J. A. Rowland, U. S. Department of the Interior, Bureau of Mines, Washington , D. C. Report No. 6116, 1962
(16 pages, 11 figures, 4 tables)

A study of damping capacity was made on a number of magnesium-base alloys, commercial types and experimental compositions. Hardness and tensile properties were determined, and the microstructure of each alloy was examined. Alloys of low yield strength, in general, possessed high damping ability. A correlation was established between damping capacity and composition.

Silicon

49776 EFFECT OF AN ELECTRIC FIELD ON SILICON OXIDATION. P. J. Jorgensen, Reprint from Journal of Chemical Physics, v. 37, no. 4, August 15, 1962, p. 874-877 (4 pages)

Modified-marker experiments have shown that silicon oxidation is controlled by the diffusion of oxygen through the silicon-dioxide film.

The application of an electric field across the silicon-dioxide layer enhances oxidation when the silicon is made positive with respect to the oxide-gas interface, and retards oxidation when the silicon is negative with respect to the oxide-gas interface. Oxidation under a retarding electric field ceases when the voltage developed across the growing oxide is equivalent to the change in free energy of the oxidation reaction.

The dependence of the oxidation rate on an electric field indicates that oxygen ions are the predominant species diffusing through the growing oxide film.

NONMETALLICS

49656 BIBLIOGRAPHY AND TABULATION OF DAMPING PROPERTIES OF NON-METALLIC MATERIALS. S. H. Chi, University of Minnesota, Minneapolis, Minnesota. WADD TR 60-540, September 1962, Report, Contract No. AF 33(657)-7453 (60 references, 147 pages, 8 figures, 4 tables)

This bibliography was compiled as an aid for those people interested in damping research and related fields. It contains a nearly complete list of references on the damping properties of nonmetallic materials for the period from 1929 to 1959, together with an index of nomenclature, units, and test methods. Tabulations of the in-phase and out-of-phase components of Young's modulus and the shear modulus for the various materials are also shown, and graphical representations of experimental data indicate the loss-factor values for different materials. These values of the loss factor are compared to those of the representative structural metals.

A detailed code-classification system for the field of damping is also described, and an abstract of each referenced article together with a coded supplement is also included in this report.

Carbon, Graphite

49572 RESEARCH AND DEVELOPMENT ON ADVANCED GRAPHITE MATERIALS VOLUME XI. E. de Ruiter, A. Halleux, V. Sandor, and H. Tschamler, Union Carbide European Research Associates, Brussels, Belgium. WADD TR 61-72, Volume XI, September 1962, Technical Report, Contract No. AF 33(616)-6915
(18 references, 23 pages, 2 figures, 10 tables)

A series of chemical and physical methods, previously developed for use in the study of the constitution of coals, has been applied to the definition of structural parameters for thirteen tar and pitch samples which have a wide range of properties and which are of interest in the fabrication of graphite bodies.

Information obtained on the molecular size and composition indicates the presence of polycyclic compounds with a high degree of aromaticity. Evidence also points to the importance of large aromatic clusters.

49647 MATERIALS AND STRUCTURES - PHYSICAL MEASUREMENTS PROGRAM PYROLYTIC GRAPHITE. J. H. Richardson and E. H. Zehms, Aerospace Corporation, El Segundo, California. DCAS TDR 62-187, October 1, 1962, Report No. TDR-69(2240-64)TR-2, Semiannual Technical Report, Contract No. AF 04(695)-69
(3 references, 20 pages, 14 figures, 2 tables)

Studies on pyrolytic graphite have been made with respect to its possible use as a re-entry heat shield material. Preliminary work is reported on changes in X-ray parameters and physical dimensions caused by heat treatment above the temperature of deposition. Data are presented which indicate that the pyrolytic structure becomes similar to that of natural graphite after treatment to 3000 C. Initial studies on structural changes as a function of time are reported.

49711 FRICTION AND WEAR AT ELEVATED TEMPERATURES. E. Rabinowicz and M. Imai, Massachusetts Institute of Technology, Cambridge, Massachusetts. WADC TR 59-603, Part III, July 1962, Final Report, Contract No. AF 33(616)-7648
(8 references, 40 pages, 24 figures, 3 tables)

A number of substances have been examined for suitability under sliding conditions in the range from room temperature to 2000 F. Low-melting metals applied as surface coatings show a peak in their friction at their melting points, unless they form an oxide with good lubricating ability. Pyrolytic boron nitride and graphite have the same friction and wear properties as do ordinary forms of these materials. A discussion is presented of how information may be obtained systematically from friction-temperature runs, and examples of the various technigues are given.

49712 RESEARCH AND DEVELOPMENT OF ADVANCED GRAPHITE MATERIALS VOLUME II-APPLICATIONS OF ANISOTROPIC ELASTIC CONTINUUM THEORY OF DISLOCATIONS IN GRAPHITE. G. B. Spence, Union Carbide Corporation, National Carbon Company, Parma, Ohio. WADD TR 61-72, Volume II, July 1962, Contract No. AF 33(616)-6915
(27 references, 48 pages, 16 figures, 5 tables)

49712 (Continued)

The theory of dislocations in an anisotropic-elastic continuum has been used to derive formulas not involving complex numbers for the stress components of straight dislocations in certain symmetry directions. From these the dependence of stacking-fault energy on the orientation of the Burgers vector and on the width of extended dislocations and triple partial ribbons and its dependence on the radius of curvature of extended nodes have been calculated. This theory is applied to graphite and close-packed metals. A procedure for correcting the widths observed in electron microscopy of thin films is given.

49721 AN ANALYSIS OF THE MATERIALS PROBLEM FOR THROAT INSERTS OF HIGH ENERGY SOLID PROPELLANT ROCKETS. W. H. Jones and L. J. Delaney, Institute for Defense Analyses, Washington D. C. Technical Report No. 62-19, October 1962, ARPA Contract SD-50
(52 references, 134 pages, 34 figures, 10 tables)

The materials problem for throat inserts of high-energy solid-propellant rockets is analyzed. The major conclusion is that graphite inserts can probably be designed which will withstand the thermal, mechanical, and chemical environments to be expected. The principal problem to be solved is the control of graphite erosivity. It is recommended that a research program on graphite erosion be instituted, with the objectives of: (1) fabricating graphites which are characterized by highly-reproducible erosivities; (2) accounting quantitatively for measured erosivities by theoretical treatments.

As a step towards attaining the latter goal a computer program is described which enables calculation of graphite erosion.

Special Refractories

49597 See Refractory Metals.

49646 MATERIALS AND STRUCTURES - APPLIED CERAMIC RESEARCH PROGRAM. E. G. Kendall, Aerospace Corporation, El Segundo, California. DCAS TDR 62-192, October 12, 1962, Report No. TDR-69 (2240-63)-TR-2, Semiannual Technical Report, Contract No. AF 04(695)-69
(2 references, 19 pages, 10 figures)

The major construction phase for establishing a suitable laboratory for ceramic research has been completed and the procurement of many key equipment items for this research has been concluded. Descriptions of key pieces of equipment that give the Aerospace Ceramic Laboratory a unique capability are presented.

Although construction of the laboratory has seriously hampered significant research progress, work of a qualitative exploratory nature has been performed and is reviewed.

49661 STUDIES OF THE REINFORCEMENT OF METALS WITH ULTRA HIGH STRENGTH FIBERS (WHISKERS). B. C. Raynes and R. H. Kelsey, Horizons Incorporated, Cleveland, Ohio. October 10, 1962, Final Report, Bureau of Naval Weapons, Contract No. NOw 62-0235-c
(44 pages, 5 figures, 8 tables)

High-strength aluminum-oxide fibers (whiskers) have been used to reinforce 80-20 nickel-chromium alloy and iron on a laboratory scale. The tensile strength of the nickel-chromium alloy was increased 28 per cent by the incorporation of 3.8 weight per cent alumina whiskers, with corresponding lower levels of reinforcement at lower fiber loadings.

The tensile strength of hydrogen-reduced iron was increased both at room temperature and at 900 F: at room temperature the average increase, with 8 per cent fiber loading was 34 per cent; at 900 F the average increase with the same amount of fiber was 30 per cent. The fibers were randomly oriented in the matrix. Theoretical calculation of the reinforcement which can be expected from randomly oriented fibers indicates that the observed increases in tensile strength are in the correct order of magnitude.

49711 See Carbon, Graphite.

Ceramic Oxide

49597 See Refractory Metals.

49618 ORDERING IN OXIDE SOLID SOLUTIONS. H. H. Wilson, Clemson College, Clemson, South Carolina. ASD TR 61-92, Part II, October 1962, Contract No. AF 33(616)-6870
(5 references, 10 pages, 4 figures, 1 table)

A study was made of solid solutions of magnesium oxide with manganese, iron, and cobalt oxides to determine the effect of extended heat treatment and of controlled furnace atmospheres on the formation of superlattices. Heat treatments involving temperatures up to 1350 C and times up to 600 hours were used. Furnace atmospheres were controlled so as to be either neutral, slightly oxidizing, or slightly reducing with respect to the divalent metallic ions.

Indications of ordering were found in those compositions that were heated in reducing atmospheres. A broad diffraction peak was found at 6.4 ^{A} which is three time the (002) spacing of the unordered lattices.

49646 See Special Refractories.

49657 HIGH TEMPERATURE CERAMIC STRUCTURES. N. E. Poulos, S. R. Elkins, C. A. Murphy, and J. D. Walton, Georgia Institute of Technology, Atlanta, Georgia. Final Summary Report, October 31, 1962, Bureau of Naval Weapons, Contract No. NOrd-15701
(108 pages, 32 figures, 24 tables)

Investigations during the year were concerned with the following major areas: (a) radome fabrication and material evaluations; and (b) arc-plasma flame glazing of slip cast fused silica. The larger effort was expended in the latter area.

49664 THERMAL EXPANSION IN AIR OF CERAMIC OXIDES TO 2200°C. T. H. Nielsen and M. H. Leipold, California Institute of Technology, Pasadena, California. Technical Report No. 32-297, October 30, 1962
(9 references, 25 pages, 27 figures, 3 tables)

Thermal-expansion measurements were made in an air atmosphere to 2200 C on polycrystalline single-phase ceramic oxides. Specimens were fabricated by hot-pressing, slip-casting, and isostatic pressing. Magnesium oxide was tested in both air and argon; calcium oxide, as well as magnesium aluminate, and aluminum oxide specimens were tested in air. Specimens were characterized as to purity, thermal history, apparent density, grain size, and lattice parameter.

It was determined that the coefficient of thermal expansion was not affected by changes in grain size or fabrication techniques. All of the specimens tested in an air atmosphere showed weight and lattice parameter stability, whereas the magnesium oxide tested in argon did not. When tested in an air atmosphere, magnesium oxide, aluminum oxide, and magnesium aluminate spinel showed a permanent expansion with a decrease in density at temperatures well below their melting points.

49779 DEVELOPMENT OF FABRICATION TECHNIQUES FOR BERYLLIUM OXIDE RADOME MATERIALS. National Beryllia Corporation, Haskell, New Jersey. Bureau of Naval Weapons, Final Report, June 1961, Contract No. NOw-60-0057c, AD 260897 (12 references, 39 pages, 15 figures, 6 tables)

The objective of this Contract was to study the effect of processing variables such as density, crystal size, and chemical purity on the dielectric and related physical properties of beryllium-oxide radome materials.

Advanced requirements for missile radomes have dictated the need for materials which combine high temperature resistance with good electrical properties. Considerable research and development has been conducted on the evaluation of various ceramic compositions in the past for such applications.

REFRACTORY METALS

49550 See Stainless Steels.

49597 MATERIALS AND STRUCTURES. H. Conrad, Aerospace Corporation, El Segundo, California. DCAS TDR 62-63, February 28, 1962, Semiannual Technical Report, Contract No. AF 04(647)-930, AD 276165
(8 pages, 4 figures)

Major effort has been spent on the problem of the ductile-to-brittle transition in the body-centered-cubic refractory metals, particularly toward understanding the mechanisms responsible for the yield point in these materials and for the strong temperature dependence of the yield and flow stress. As a result a new interpretation of the yield point was developed, and it was proposed that the tendency for brittleness in the refractory metals is due to the inherent resistance of the body-centered-cubic lattice to the motion of dislocations.

The other area in which significant progress was made is brittle fracture of ceramics. Work on sapphire (a-Al_2O_3) crystals showed that plastic flow and twinning play an important role in the fracture of sapphire. It was found that the effect of temperature on the fracture stress in the range of 1000 - 1500 C is related to the amount of deformation a specimen undergoes prior to fracture, rather than a direct effect of temperature on the fracture stress.

49783 WORK HARDENING MECHANISMS IN BODY CENTERED CUBIC METALS. D. P. Gregory, G. H. Rowe, and A. N. Stroh, Pratt and Whitney Aircraft Corp., CANEL, Middletown, Connecticut. ASD-TDR-62-354, September 1962, Technical Documentary Report, Contract No. AF 33(616)-7855
(85 references, 121 pages, numerous figures, 5 tables)

The first section of this report contains a survey and analysis of the work-hardening literature.

The second section describes results of an experimental work-hardening program with polycrystalline and single-crystal columbium. Work-hardening mechanisms were deduced from results of (1) tensile studies at strain rates varying from 0.002 min^{-1} to 20 min^{-1} and at temperatures varying from -196 C to 100 C, (2) strain-rate-cycling tests conducted at various temperatures and strain rates, (3) temperature-cycling tests conducted at two mean temperatures, -39 C and +50 C at constant strain rate, and (4) transmission-electron-microscopy studies conducted on specimens deformed at temperatures from -196 C to 24 C. The columbium consisted of polycrystalline material of nominal impurity content in a variety of conditions ranging from wrought, recovered, fine-grain, and electron-beam zone-refined single crystals.

Work hardening in fine grain columbium polycrystals containing several hundred ppm interstitial impurity at 50 C results from a decrease in both the number of mobile dislocations and the activation volume with increasing strain. The particular mechanism responsible for work hardening appears to be nonconservative motion of jogs in screw dislocations which results in the formation of lattice vacancies.

Columbium

49569 DEVELOPMENT AND PROPERTIES OF COLUMBIUM-10% TUNGSTEN-10% HAFNIUM ALLOY. R. T. Torgerson, The Boeing Company, Seattle, Washington. Paper presented at the 1962 Fall Meeting of the Metallurgical Society of AIME, New York, New York, October 29-November 1, 1962
(2 references, 58 pages, 21 figures, 15 tables)

An alloy with the composition Cb-10W-10Hf exhibited a promising combination of fabricability and high temperature strength, and was selected for further development. This columbium alloy was given the designation C-129 alloy. Two heats consisting of 4-inch diameter ingots and one heat consisting of an 8-inch diameter ingot, were fabricated into sheet. The resulting sheet was evaluated for properties to determine the usage potential of this alloy for high-temperature structural applications. Tensile properties, forming characteristics, welding parameters, recrystallization characteristics, ductile-brittle transition data, and coatability of C-129 alloy are presented.

49652 See Nickel Base.

49666 See Tantalum.

49790 REFRACTORY METALS STRUCTURAL DEVELOPMENT PROGRAM: VOL. III DESIGN, FABRICATION AND TESTING EVALUATION. C. W. Neff and R. G. Frank, McDonnell Aircraft Corp., St. Louis, Missouri and General Electric Co., Evendale, Ohio. ASD TR 61-392, Vol. III, September 1962, Technical Report, Contract No. AF 33(616)- 6578
(195 pages, 183 figures, 40 tables)

The purpose of this program was to design, fabricate, and test a representative load-carrying structural component capable of efficient operation in the temperature range of 1800 F. The component was designed to be temperature resistant and entirely self-sustaining in the above-mentioned temperature range with no auxiliary insulating or cooling devices.

The data compiled within this volume of the final report describe the processes involved to evaluate various designs and fabrication techniques prior to final-component design and fabrication.

Basically, the final component was fabricated from columbium (F-48) and a General Electric LB-2 (aluminum-chromium-silicon) slurry coating was used for oxidation protection of the component parts with the exception of fasteners. The fasteners used for final assembly were coated with Thompson Ramo Wooldridge (TRW) vapor-deposited coating. All the fusion-welded fittings were fabricated from Fansteel FS-82 alloy. The inboard-rudder panels were fabricated from L-605 while the inboard-fin panels were fabricated from columbium 1 per cent Zr.

Molybdenum

49652 See Nickel Base.

49666 See Tantalum.

49739 THE EXTRUSION, FORGING, ROLLING, AND EVALUATION OF REFRACTORY ALLOYS. D. R. Carnahan and J. A. Visconti, Westinghouse Electric Corporation, Blairsville, Pennsylvania. ASD TDR 62-670, October 1962, Final Report, Contract No. AF 33(616)-8325
(105 pages, 29 figures, 26 tables)

During the present contract year metallurgical programs were conducted on the extrusion, forging, and rolling of arc-cast Mo 25%Ti 0.08%Zr 0.02%C and W 0.57%Cb alloys. Each of the three alloys has been worked successfully by extrusion and subsequent reworking.

The extrusion process, as established in previous work, has remained primarily the same. However, extrusion temperatures exceeding 4200 F have been reached in the working of a group of tungsten base alloys. The maximum temperature attained to date has been 4320 F.

In addition, the extrusion process has been applied to a variety of refractory alloys in order to supply wrought material for other contractors and governmental agencies. The extrusion data are contained as a portion of the work, but the metallurgical evaluation is not included, as it is accomplished by the particular agency for which the work was performed.

Tantalum

49651 THE MECHANICAL PROPERTIES OF TANTALUM WITH SPECIAL REFERENCE TO THE DUCTILE-BRITTLE TRANSITION. G. T. Murray and R. A. Burn, Materials Research Corporation, Orangeburg, New York. ASD TR 61-203, Pt. II, June 1962, Contract No. AF 33(616)-7173
(14 references, 45 pages, 19 figures, 8 tables)

The lower-yield stress-grain-size relationship was studied in tantalum for two compositions; one consisting of a total interstitial content of 72 ppm with the major constituent being oxygen, and the other containing primarily carbon (116 ppm) in which part of the carbon existed in the form of a finely dispersed carbide precipitate. These results were compared to those obtained earlier on commercial tantalum containing a total interstitial content of about 200 ppm.

The commercial tantalum exhibited significantly higher yield and flow stresses and correspondingly high σ_i values. The carbon containing material showed the lowest yield stresses primarily because of its lower oxygen content. It was concluded that oxygen is much more effective than carbon in restricting dislocation movement. The effect of the carbide precipitate was to increase the work-hardening rate. The flow stresses, however, even in the presence of the carbide phase were lower than those observed for commercial tantalum.

49666 SUBSTRUCTURE AND MECHANICAL PROPERTIES OF REFRACTORY METALS. B. S. Lement, D. A. Thomas, S. Weissmann, W. S. Owen, and P. B. Hirsch, Manufacturing Laboratories, Inc., Cambridge, Massachusetts. WADD TR 61-181, Part II, October 1962, Final Report, Contract No. AF 33(616)-6838
(4 references, 269 pages, 170 figures, 37 tables)

A coordinated program on substructural characteristics of tungsten, molybdenum, tantalum, and columbium was carried out by means of advanced microscopic, X-ray diffraction, and mechanical testing techniques. Initial increase in hardness during recovery of heavily deformed tungsten wire is ascribed to segregation of interstitials to dislocations and to microtwinning. Sharp drop in ductility on 1100 C anneal is attributed to rise in transition temperature to above room temperature due to increase in fiber width. Competing processes of polygonization and strain-induced fiber-boundary migration occur up to 1400 C. In tantalum single crystals, the maximum principal strain changes from positive to negative on deforming below and above the upper yield point respectively. Binding energy between dislocations and interstitials in tantalum is about 0.53 e.v. For low interstitial contents, k_y increases as the dislocation density is decreased by higher annealing above recrystallization; for high interstitial contents, k_y is not affected. The activation energy for annealing-out of dislocation loops in tantalum and columbium is about 3 e.v.

Vanadium

49663 DEVELOPMENT OF IMPROVED VANADIUM-BASE ALLOYS FOR ELEVATED-TEMPERATURE USE.
V. C. Petersen and H. B. Bomberger, Crucible Steel Company of America, Pittsburgh, Pennsylvania. ASD TDR 62-667, October 1962, Final Report, Contract No. AF 33(616)-7288
(66 pages, 26 figures, 10 tables)

Work was done to develop vanadium-base alloys having improved mechanical properties at elevated temperatures. The screening criteria included density-corrected hot hardness at 1800 F as well as forgeability performance at 2300 F. The hot-hardness apparatus designed for the work permits loading up to 14 specimens at one time and testing up to 1800 F in vacuum. The validity of hot hardness as a hot-strength parameter was established by a correlation with hot-strength data. In the exploratory work, 174 binary and multi-addition alloys were levitation-melted in 10-gram charges. Based on these studies of the microstructures, forgeability, and hot hardness of these alloys, 14 compositions were selected as most promising and were scaled up to larger melts. Screening data (rollability, hot hardness, and hot tensile properties) on the larger melts showed three compositions to be superior: V-20Cb-5Ti, V-25Mo-2.5Hf, and V-35Cr-1Zr. These alloys demonstrated better forgeability and superior 2000 F tensile strength than the well-known V-20Cb-5Ti alloy. Iron and tin were also found to be promising alloying elements for further study.

Tungsten

49574 TUNGSTEN SHEET ROLLING PROGRAM - PHASE III - FINAL REPORT. W. J. Schoenfeld, Universal-Cyclops Steel Corporation, Bridgeville, Pennsylvania. ASC TR 7-827 (V), November 1962, 5th Interim Report, Contract No. AF 33(600)-41917
(54 pages, 24 figures)

Rolling and evaluation of the Phase III material has been completed. The effect of various processing parameters on workability and final properties is documented.

Significant conclusions from the phase III work are as follows:

(1) Extrusion to rounds or to rectangular cross-section sheet bar can be accomplished equally well
(2) Initial rolling of extruded or extruded- and forged product can be and is best accomplished in the temperature range of 2300 F
(3) In order to achieve the lowest ductile-brittle transition, final rolling temperatures should not exceed 1550 F
(4) Cross rolling improves both the longitudinal and the transverse bend and tensile properties.

49576 DEVELOPMENT OF ROLL-FORMED TUNGSTEN NOZZLE COMPONENTS. General Electric Company, Cincinnati, Ohio. August 31, 1962, Final Report, Bureau of Naval Weapons, Contract No. NOw 61-0161-c (FBM)
(2 references, 45 pages, 24 figures, 1 table)

The shear forming and spinning of commercially available tungsten sheet into nozzle parts of various configurations was demonstrated in this contract. The design configurations included convergent/divergent throat sections, "bent-back" and minimum-radius flanges, and uniform wall thickness over the length and contour of the part.

The nozzle parts were fitted and bonded to graphite substrates and were designed to be included as components of nozzle assemblies.

49577 OXIDATION OF TUNGSTEN AT ULTRA-HIGH TEMPERATURES. R. A. Perkins, W. L. Price, and D. D. Crooks, Lockheed Aircraft Corporation, Sunnyvale, California. Technical Report, 6-90-62-98, November 1962
(8 references, 39 pages, 12 figures, 2 tables)

Equations which predict rates of oxidation of tungsten in air and oxygen at pressures of 10^{-6} to 3.0 mm Hg within $\pm$20 per cent of experimental values from three independent investigations are presented.

49652 See Nickel Base.

49666 See Tantalum.

49739 See Molybdenum.

49784 DIFFUSION BONDING OF TUNGSTEN ALLOYS. G. K. Hickox, Aerojet-General Corporation, Sacramento, California. Technical Report, WAL TR 465.54/4, November 15, 1962, Final Report No. 0433-01F, for Watertown Arsenal, Contract No. DA-04-200-ORD-1077
(numerous pages, 42 figures, 11 tables)

49784 (Continued)

The program includes investigations of brazing fundamentals, tungsten forming and recrystallization behavior, brazing-filler metals, and diffusion treatments. Final evaluation of the diffusion-bonding concept was performed by the fabrication and firing of two solid-rocket motors with diffusion-bonded nozzles.

Platinum Group

49704 See Composites.

MISCELLANEOUS

49632 AN EVALUATION OF THE SPACE STORABILITY OF PROPELLANTS. W. R. Davison and J. P. Carstens, United Aircraft Corporation, East Hartford, Connecticut. American Rocket Society Paper No. 2723-62 presented at the 17th Annual Meeting and Space Flight Exposition, Los Angeles, California, November 13-18, 1962
(27 pages, 11 figures)

An investigation of the various factors to be considered in assessing the storability and performance characteristics of a given propellant combination is presented. Storability effects are represented by the additional vehicle weight incurred in maintaining the propellant during some mission waiting time. The design effects of structural heat leaks and insulation type are described. Three different types of storage systems are considered: vented (constant pressure), nonvented (constant volume), and refrigerated. Stage weights, including storability-penalty weights, are calculated for two missions: a lunar surface mission and an earth-orbital mission. The stage weights are compared on the basis of theoretical-performance characteristics of the following propellant combinations: hydrogen-oxygen (H_2-O_2), hydrogen-fluorine (H_2-F_2), hydrazine-nitrogen tetroxide (N_2H_4-N_2O_4) and diborane-oxygen difluoride (B_2H_6-OF_2).

49655 See Composites.

49672 STANDARDIZATION OF THERMAL EMITTANCE MEASUREMENTS PART III. W. N. Harrison, J. C. Richmond, and H. K. Skramstad, National Bureau of Standards, Washington, D. C. WADC TR 59-510, Part III, March 1962, Interim Report, Contract No. AF 33(616)-61-02 AD 275613
(33 pages, 15 figures, 1 table)

Equipment for direct measurement of normal spectral emittance was modified in several respects. The test procedure was changed by incorporation of a "zero line" correction. The equipment was calibrated by means of sector-disc attenuators which passed known factions of the radiant flux from a blackbody furnace. Equipment for automatic recording of spectral data in a form suitable for direct entry into an electronic computer, and on-line computation of total emittance or solar absorptance, was designed. Working standards of normal spectral emittance were prepared and calibrated. An equation relating the normal spectral emissivity to five other parameters of a metal was solved "by hand" for one set of data. Some progress was made in setting up a program for solution of the equation by use of an electronic computer.

49693 CRITERIA FOR PLASTIC ABLATION MATERIALS AS FUNCTIONS OF ENVIRONMENTAL PARAMETERS - PART II. V. M. Vila and D. Nilsson, Aerojet-General Corporation, Azusa, California. ASD TR 61-439, Part II, May 1962, Contract No. AF 33(616)-7401 AD 277951
(148 pages)

Reports presenting ablation information and related technology have been compiled and abstracted. Ablation information abstracts of the various

49693 (Continued)

reports with author, corporate, and subject indexes are presented. The abstracted reports presented are believed to represent 35 per cent of the available literature on the subject of ablation and related technology. Abstracts of 243 reports are presented.

49708 PROCEDURES FOR THE DESIGN OF THERMAL PROTECTION SYSTEMS FOR MANEUVERABLE RE-ENTRY VEHICLES. D. Turrentine, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio. ASD TDR 62-625, September 1962
(17 references, 73 pages, 33 figures, 1 table)

Atmospheric re-entry of earth-orbital hypersonic-glide vehicles creates thermal problems. The heat affects not only the materials and construction of the airframe but also the crew and various subsystems of the vehicle. Successful solution of these problems depends upon the development of an effective thermal-protective concept, which will also give the designer some latitude in his design philosophy. The role of the protective system is to significantly attenuate the influx of heat that is aerodynamically generated within the surrounding boundary layer. Attenuation is accomplished by combining external radiation-shielding elements with backup insulation materials and an appropriate cooling system.

Analytical procedures are presented for determining sifnificant system parameters by transforming the differential-heat conduction or diffusion equation into an algebraic expression by employing the calculus of finite differences. The adaptation of the resulting equation to digital-computer programming is discussed, and numerical results are presented to indicate systems of minimum weight.

49775 See Stainless Steels.

49778 EXPERIMENTAL DETERMINATION OF THE THERMAL RADIATION PROPERTIES OF TEMPERATURE CONTROL SURFACES FOR SPACECRAFT. E. R. Streed, Spacecraft Thermodynamics Symposium, LMSC Research Lab., Palo Alto, California. March 28, 1962, Reprint 5-76-62-7, AD 276052
(3 references, 14 pages, 7 figures)

More versatile, reliable, and sophisticated spacecraft and payloads demand continued measurement of the radiation characteristics of existing and promising thermal-control surfaces. Measurements are being performed for (1) optical materials research, (2) coating-surface finish development, (3) precise data for thermal-design purposes, and (4) production control and final inspection. Examples of work performed in each of these areas and a description of the equipment used are presented. Techniques and apparatus utilizing reflectance, absorptance, and emittance phenomena are described for the solar and infrared-spectral regions.

49780 THE SPACE ENVIRONMENT AND ITS INTERACTIONS WITH LIQUID PROPELLANTS AND THEIR STORAGE SYSTEMS. N. M. Wiederhorn, Arthur D. Little, Inc., Cambridge, Massachusetts. Report No. 63270-02-1, September 1961, Technical Report for NASA, Contract No. NAS 5-664, AD 266034
(47 references, 102 pages, 10 figures, 3 tables)

49780 (Continued)

The storage of liquid propellants on the surface of the moon or in space vehicles, which are in orbit or interplanetary flight, presents a series of unusual problems. NASA established a program to elucidate the problem areas and provide engineering approaches to their solution. Objectives are to define the mechanisms that affect the storage of propellants, to investigate systems to obviate or minimize deleterious effects, and to determine the magnitude of losses and penalties associated with various systems. In order to accomplish this, it is necessary to have a quantitative statement of these factors in the space environment that can produce significant effects in storage systems.

Sections are devoted to a discussion of the pertinent factors of the space environment that influence the storage of liquid propellants in space and the mechanisms whereby these may interact with a liquid propellant or its storage system. In addition to this discussion, an extensive bibliography, including abstracts, is contained in this report. This bibliography provides a survey of the space environment, which is a prerequisite to the consideration and study of any interaction or effects which might occur in the environment of space.

Coatings

49657 See Ceramic Oxide.

49790 See Columbium.

49550 See Stainless Steels.

49576 See Tungsten.

49647 See Carbon, Graphite.

49657 See Ceramic Oxide.

49703 See Composites.

49705 See Composites.

49708 See Miscellaneous.

49721 See Carbon, Graphite.

49724 See Magnesium.

49774 See High-Strength Alloys.

49777 See Composites.

49778 See Miscellaneous.

49781 STRAIN DISTRIBUTION ON NOTCHED PLATE SPECIMENS AT CREEP TEMPERATURES. H. R. Voorhees and J. W. Freeman, University of Michigan, Ann Arbor, Michigan. ASD-TDR-62-710, August 1962, Technical Documentary Report, Contract No. AF 33(616)-7416
(50 pages, 18 figures, 5 tables)

Resistance-strain gages and grids of vapor-deposited metal were evaluated for measuring strains at loading and during creep in plates with edge notches. Foil strain gages mounted with thermal-setting cements remained usable to 0.5 per cent or higher strain at 500 F, but indicated creep was first less than, and later more than, optical-extensometer readings. Indications from gages mounted with ceramic cement drifted 10 inches per mph after several hundred hours at temperature, but agreed with the extensometer to one per cent strain. Qualitative measurements were made during loading (K_t 1.8 and 3.6) and for creep (K_t 1.8) of M-470 alloy at 500 F. Plastic strains were too small to determine by the grid lines used.

49790 See Columbium.

Composites

49550 See Stainless Steels.

49552 DETERMINATION OF THE PERFORMANCE OF PLASTIC LAMINATES UNDER CRYOGENIC TEMPERATURES. N. O. Brink, Narmco Research & Development Corporation, San Diego, California. ASD TDR 62-794, August, 1962, Contract No. AF 33(616)-8289
(64 pages, 32 figures, 8 tables)

The main objective of this program was to determine the performance of various reinforced-plastic laminates at different cryogenic temperatures. Ten materials were evaluated, and represented the epoxy, phenolic, polyester, high-temperature polyester, and silicone-resin systems. The materials were tested in tension, compression, flexure, and tensile fatigue. Test temperatures included room, -110 F (dry ice and alcohol), -320 F (liquid nitrogen), and -424 F (liquid hydrogen).

49608 HIGH-TEMPERATURE RESISTANT BERYLLIA FIBER-REINFORCED STRUCTURAL COMPOSITES. National Beryllia Corporation, Haskell, New Jersey. ASD TDR 62-632, July 1962, Contract No. AF 33(616)-8066
(14 references, 101 pages, 32 figures, 8 tables)

Research and development work has been conducted with the aim of obtaining new and improved reinforcing materials for structural composites. Of the various types of materials suitable for advanced high-temperature reinforcements, beryllium oxide (BeO) shows a strong potential because of its combination of high-melting point (4650 F) and low density (3.0 gm/cc). High-purity BeO fibers have been prepared by two methods with reproducible results; the first, evaporation of BeO by water vapor at high temperatures with subsequent condensation as BeO fibers; and the second, oxidation of beryllium metal in a hydrogen-carrier gas with condensation of monocrystalline highly-oriented BeO fibers. Best quality and mechanical properties have been found in the latter type. Such pure BeO monocrystalline fibers have been grown in lengths of 1¼ inches with a thickness of approximately 0.0005 inch.

49612 HIGH MODULUS, HIGH STRENGTH HEAT RESISTANT REINFORCEMENTS. A. R. Morrison, R. Wong, and W. C. Brady, Owens-Corning Fiberglas Corporation, Toledo, Ohio. ASD TDR 62-747, August 1962, Contract No. AF 33(616)-7950
(48 pages, 10 figures, 20 tables)

A program to optimize the properties of and to develop fiberization techniques for X-994 glass resulted in the formation of fibers having an average tensile strength of 650,000 psi at room temperature and 123,000 psi at 1500 F. Fiberization techniques were developed to the extent that X-994 fiber can now be produced on a semi-commercial basis.

Inorganic surface treatments were found to improve the tensile strength and abrasive resistance of X-994- and E-glass fibers at elevated temperatures. These treatments also gave some protection to fibers from the corrosive attack of inorganic matrices.

The effect of a series of proprietary treatments on the properties of Ym31A, X-994, and E-glass fibers were determined.

49655 INITIAL WEIGHT LOSS OF PLASTICS IN A VACUUM AT TEMPERATURES FROM 80° TO 500°F. H. R. Gloria, W. J. Stewart, and R. C. Savin, Ames Research Center, Moffett Field, California. NASA TN D-1329, December 1962, (13 references, 19 pages, 8 figures)

Initial rates of weight loss are determined for five plastic materials at pressures from 3 x 10^{-7} to 3 x 10^{-6} mm Hg and at temperatures ranging from 80 to 500 F. The materials tested include two thermoplastics-polytetrafluoroethylene and polycarbonate-two types of reinforced phenolics and a relatively pure epoxy resin. The effect of material thickness on initial rate of weight loss for all the test materials is also presented.

49656 See Nonmetallics.

49695 MICROSCOPIC STUDY OF MODE OF FRACTURE IN FILAMENT WOUND GLASS-RESIN COMPOSITES. C. A. Bouc, University of Illinois, Urbana, Illinois. T&AM Report No. 234, November 1962, Technical Memo No. 189, Naval Research Laboratory, Contract No. Nonr 2947(02)(x)
(10 references, 31 pages, 32 figures, 5 tables)

Filament-wound glass-resin specimens were successfully developed to approximately simulate a typical filament-wound composite such as are found in pressure vessels and fuel tanks. During tensile loading, each specimen was carefully scanned through a microscope at a magnification of x200, and a written and photographic record was made of the progress of the fracture phenomena. The information thus obtained was synthesized into identification of five different microscopic modes of fracture. The origin and nature of these different fracture modes was investigated with the aid of micro-photographs, and their contribution to the progressive and ultimate fracture of the specimens determined.

49703 PROPERTIES OF GLASSES AT ELEVATED TEMPERATURES. M. J. Kerper, T. G. Scuderi, and E. H. Eimer, National Bureau of Standards, Washington, D. C. WADC TR 56-645, Part VI, August 1962, Contract No. AF 33(616)-59-4
(10 references, 89 pages, 32 figures, 22 tables)

In order to establish realistic design criteria applicable to selected oxide glasses having utility as viewing windows in Air Force vehicles, certain physical properties have been determined throughout the useful temperature range of the glasses.

Data are presented on several glasses at the top temperature at which short-time modulus of rupture testing can be conducted. The stress-rupture results for all seven glasses in the program are presented. Creep results obtained on Pittsburgh Plate Glass 6695 are also given.

Equations have been developed to represent the relationship of the "mirror radius" on the fracture surface to the modulus-of-rupture data.

An analysis of the distribution of strength values of glass was carried out. The data show essentially that glass does fit normal theory with certain reservations.

A description of the apparatus used for determining the relationship between strength and size together with some preliminary findings regarding this relationship are presented.

49704 REFLECTIVE COATINGS ON POLYMERIC SUBSTRATES. R. B. Belser and M. D. Carithers, Georgia Institute of Technology, Atlanta, Georgia. ASD TR 61-151, Part II, July 1962, Contract No. AF 33(616)-6980
(8 references, 101 pages, 25 figures, 10 tables)

Methods of overcoating metal surfaces with polymer coatings to provide a surface of high gloss plus reflective-metal films for controlling the optical properties of a metal surface were examined.

Polymers of the species epoxy, polyurethane, or silicone were applied to stainless steel substrates and were overcoated with metal films of gold, silver aluminum, copper, nickel, or combinations by chemical-reduction or vacuum-deposition techniques.

The polymers and the metal films were examined for adherence, survival from 25 to 200 C, specular reflectance and emittance at various temperatures.

Reflectance values of metallic films evaporated or chemically deposited on polymeric substrates were generally equivalent and were equal to that obtained for similar metallic films on glass substrates.

49705 EXPANDABLE RIGIDIZABLE STRUCTURES. T. L. Graham, Nonmetallic Materials Laboratory, Wright-Patterson Air Force Base, Ohio. ASD TDR 62-311, May 1962,
(2 references, 24 pages, 4 figures, 5 tables)

A new concept has been preliminarily investigated by which initially-flexible impregnated-fibrous-composite structures can be rigidized after expansion due to crosslinking of the impregnant which is induced by selected inflating gases.

Members of two classes of resin intermediates, the epoxides and the ruethanes, which cure when exposed to amine and moisture-vapor environments, respectively, have been investigated. The chemical structures and the reaction mechanism of these resin intermediates are discussed. Data are presented showing the strength of structural-laminate samples rigidized by this method in which resin-catalyst systems were used. The permeability characteristics of candidate expandable structures for inner liners to an amine catalyst are given. Expandable structures successfully rigidized using amine-epoxy resin systems are described.

49706 HEAT RESISTANT LAMINATING RESINS. L. Gilman, S. F. Bedell, J. H. Cornell, R. E. Debrunner, C. E. Hathaway, M. J. Karten, and J. J. O'Connell, Monsanto Chemical Company, Everett, Massachusetts. WADC TR 59-328, Part II, May 1962, Contract No. AF 33(616)-6956
(21 references, 76 pages, 8 figures, 15 tables)

Polyisocyanurate laminates have been prepared having original flexural strengths at room temperature from about 60,000 to 80,000 psi and flexural moduli approximately 4.5×10^6 psi. Flexural strengths at 500 F have been from 30,000 to 45,000 psi. Thus, mechanical properties have been markedly improved over initial values, but good strength at the desired temperature of 700 F has not been attained.

Glass-fabric-reinforced-plastic laminates utilizing chelate polymers were prepared. Although these initial laminates gave low strength at room and elevated temperatures, as far as is known they are the first chelate-based resins that were sufficiently advanced to permit laminate fabrication.

49706 (Continued)

Preliminary results indicate that polyisocyanurate resins may have potential as adhesives for metal-to-metal bonding.

49777 ALL-METAL SANDWICHES EXCEPT HONEYCOMB-CORE: AN ANNOTATED BIBLIOGRAPHY. E. E. Graziano, Lockheed Aircraft Corporation, Sunnyvale, California. 3-77-62-5, March 1962, Special Bibliography, SB 62-8, USAF, Contract No. AF 647/787, AD 275280
(78 pages)

The purpose of this search was to discover existing literature relating to all-metal sandwiches, except honeycomb-core, published from January 1, 1956 to date, that might be of interest in space vehicle and missile applications.